Surface Functionalization and Electrochemical Applications of Ultrananocrystalline Diamond

Scientific Achievement

Control and manipulation of surface chemistry of ultrananocrystalline diamond (UNCD) thin film are essential in tailoring its properties for high demand specific applications. Along this line, we continue to develop different strategies for surface modification/functionalization and interfacial engineering of UNCD thin film. We have demonstrated that the integration of electrocatalyst particles (e. g., Pt) with UNCD could achieve a dimensionally stable composite electrode with controllable electrocatalytic activity, which is particular useful in harsh chemical environments under demanding electrochemical conditions. The integration of soft materials with UNCD allows us to control over UNCD surface hydrophobicity and surface charges to achieve optimal surface bioinertness and biocompatibility. Polymer brushes (polystyrene or poly (methyl methacrylate)) can be covalently immobilized onto UNCD surface based on the surface–initiated atom transfer radical polymerization. The polymer modified surfaces strongly suppress the non-specific protein adsorption. We have also demonstrated that protein micropatterning on UNCD surface could be achieved via photochemical activation of arylazide-biotin conjugate. The biotinylated UNCD surface serves as an ideal platform for the attachment of biomolecules based on the biotin/avidin chemistry.

Significance

UNCD is finding numerous applications in fields such as tribology, cold cathodes, electrochemical electrodes, and MEMS devices, due to its superb tribological, electrical and electrochemical properties. These properties rely heavily on UNCD surface chemical compositions. We envision that the control and manipulation of UNCD surface property could endow UNCD many new properties and broaden UNCD applications particularly in the biochemical/biomedical field. For example, organic functionalization of UNCD surface could significantly enhance the bioinertness and biocompatibility of UNCD, which makes it a promising material for hermetic encapsulation of implantable biodevices. On the other hand, UNCD thin film is an excellent electronic material. The integration of biological functions with UNCD-based microelectronics may enable the development of biosensing systems with enhanced selectivity, sensitivity and stability. The significance of this work has been recognized by the diamond research community (invited presentation at the *MRS Spring Meeting 2005*), and the work has been published in *Diamond and Related Materials*, (online Oct. 17, 2005 and Jan. 1**8,** 2006).

Performers

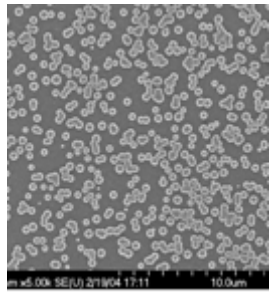
J. Wang, N. Naguib, C. Liu (ANL-MSD), O. Auciello, and J. A. Carlisle (ANL-MSD & CNM)

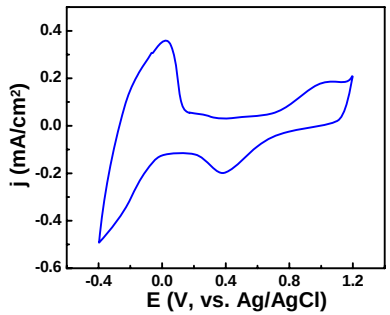
Surface Functionalization and Electrochemical Applications of Ultrananocrystalline Diamond

Motivations

Bio/organic surface functionalization of UNCD thin films provides the incorporation of many new properties, including catalytic activity, lubrication, optical response, molecular recognition, and biocompatibility, and could enable potential applications such as biosensors, biomedical implants, and organic/biomolecular electronics.

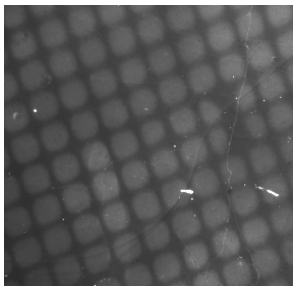
Incorporation of Pt Particles onto UNCD

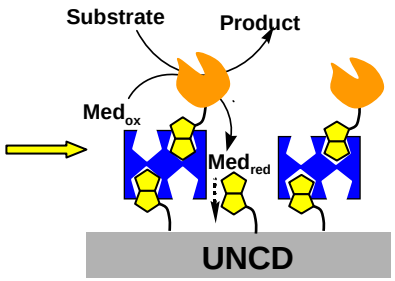




Dimensionally stable electrodes for electrocatalysis and electrosynthesis.

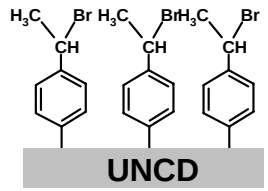
Protein Micropatterning on UNCD

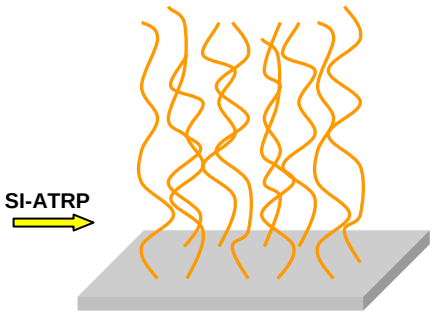




Localized Protein immobilization onto UNCD surface for electrochemical biosensing.

Covalent Attachment of Polymer Brushes





Control over UNCD surface hydrophobicity and charges, and suppress biofouling.

J. Wang, N. Naguib, C. Liu, O. Auciello, and J. A. Carlisle.

Materials Science Division
ARGONNE NATIONAL LABORATORY

M.M. Chehimi (University Paris, France).